telephone and about 1 million people are unable to use the telephone.[6] Different disabilities create quite different needs. Disabilities may affect mobility, vision, hearing, hand motion, cognition, or other activities. Let us consider some of the communications needs associated with several of those disabilities.

A. Mobility Disabilities

Consider first a person with a mobility disability — for example, someone who normally uses a wheelchair. A cordless telephone or a cellular/PCS phone provides great value to such a person. When the telephone rings, he or she does not need to rush to answer it. Clearly, though, if one must carry around a portable telephone, size, weight, and battery life are important. In most such cases, a smaller unit with a longer battery life would serve the consumer's needs best.

B. Vision Disabilities

Consider a person with a vision disability — for example, someone who finds it hard to read text unless the print is large and the contrast high. A person with such a disability would find it hard to read the small LCD displays on many cellular telephones. Similarly, a person with an even more severe vision disability may be unable to use the graphical interfaces on many computers and may prefer telephones with larger keys permitting use of larger type on the keys.

C. Hearing Disabilities

Third, consider a person with a hearing disability. If the disability is severe, such a person would not be able to use a telephone.[7] Several important accessibility issues arise from the needs of the deaf and hearing-impaired community. We will discuss three of them briefly: telecoils, TTYs, and alerting devices.

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[6] Census Bureau, *Disability Status of Persons* (SIPP), Table 1, last revised Wednesday, 25-Mar-98, at http://www.census.gov/hhes/www/disable/sipp/disstat.html.

[7] Above, we cited the Census Bureau for the proposition that about 1 million people cannot use the telephone. That Census Bureau report states that 924,000 people cannot hear normal conversation and that 933,000 people cannot use the telephone. It seems reasonable to conclude that the vast majority of those who cannot use the telephone are hearing impaired.

Many hearing aids are equipped with a capability, called a *telecoil*, to pick up electrical signals directly from telephones. A telecoil makes hearing telephone calls easier. Telecoils are built into behind-the-ear and body aids, but not in-the-ear and in-the-canal aids. Telecoils were developed decades ago and took advantage of an extra, unintended magnetic field created by the telephone receivers in use at that time to connect hearing aids to telephones.[8]

Several problems have developed with telecoils, including the incompatibility of some telephones with telecoils and interference to telecoils from electronic equipment. Some more recent telephone receiver technologies do not generate the magnetic fields needed for operation of the telecoil. This problem became significant in the late 1970s and early 1980s, and Congress amended the Communications Act in 1983 to establish telecoil compatibility requirements.[9] A second problem with telecoils is their ability to respond to magnetic fields generated by electronic and electrical equipment. In particular, hearing aids with telecoils can act as tiny radio receivers and can pick up digital cellular radio transmissions or static from nearby electronic equipment.[10] As a consequence, some hearing aid users are unable to use digital cellular and PCS telephones because of a severe buzzing induced by the unwanted reception of digital signals.

Many deaf individuals use equipment called TTYs or TDDs to communicate with their family and friends.[11] *TTYs* are terminal devices with displays, keyboards, and modems that connect to

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[8] The telephone receiver is the speaker or earphone part of the telephone. The receivers in use from Bell's telephone until recently used coils of wire to generate magnetic fields that moved a sheet or membrane to vibrate air. Improved designs of such magnetic receivers or use of non-magnetic technologies reduced or eliminated the magnetic fields that telecoils depended upon.

[9] PL 97-410, 96 Stat. 2043. This statute was substantially revised in 1988.

[10] We regard the problem of incidental pickup of cellular transmissions and static from electronics as a transitional problem. Design changes in hearing aids can suppress this effect at relatively little cost. We expect that consumers would value such improvements.

We also note that the FCC may have the authority under Section 302 of the Act to regulate the interference susceptibility of hearing aids. That Section gives the FCC authority to establish minimum performance standards for home electronic equipment and systems to reduce their susceptibility to interference from radio frequency energy. If hearing aids were classified as home electronic equipment, then the FCC would appear to have authority over their interference susceptibility.

[11] The acronym TTY comes from teletypewriter, TDD from telecommunications device for the deaf.

telephones and permit written (typed) conversation over telephone connections. The original TTYs were converted obsolete teletype machines using the 5-bit Baudot code that had been replaced by ASCII. These machines were donated to the deaf community by the operators of teletype networks and were often refurbished by volunteers from the industry. Modern TTYs are electronic devices, but they still use the old Baudot code for compatibility with other TTYs.

TTYs encounter a number of compatibility problems in working with modern computer and information technology equipment. In addition to the fact that TTYs do not represent letters using the same patterns of bits that modern computers use (the Baudot code is so limited that it does not distinguish between upper and lower case), the data modulation used by TTYs is different from the modulation used by most computer modems — hence, a TTY cannot dial in to standard computer ports (the modulation used for TTYs was a reasonable design choice in the 1960s, but is too slow for today's computer communications needs). The digital modulation used by TTYs cannot be recorded by some digital answering machines that were designed to store human voice, not abstract tones. Similarly, the TTY tones are usually not compatible with the voice coding used on digital cellular phones.

The deaf and severely hearing impaired cannot hear the ringing of a normal telephone. Instead, they need visual indicators, such as a flashing light or particularly loud ringing to alert them that a call is coming in (for their TTY, for example).

D. Motion Disabilities

Another form of disability is a limit on the range or speed of motion or on the accurate control of hands and fingers. The needs of people with motion disabilities vary. Some individuals have limits on their range of motion and benefit from the use of compact control panels that require little movement. Others, with difficulties in control, benefit from the use of control panels with larger, separated buttons. The text below, taken from a web site on disability access, describes some of the alternative keyboards available to those with motion disabilities.

Manufacturers provide small keyboards for people with limited range of motion[12] more generally, there are a wide variety of keyboards designed to match different disabilities.

ALTERNATIVE KEYBOARDS

Mini Keyboard (TASH) is a small keyboard for a PC. It is designed for individuals who have difficulty using a standard keyboard due to limited range of motion.

Intellikeys (IntelliTools) is a large programmable keyboard with a variety of overlays designed for individuals with limited fine motor control. Only light pressure is required to activate the keys. Software is available to design custom overlays. Both Macintosh and PC versions are available.

The **Dvorak One-handed Keyboard** (Typewriting Institute for the Handicapped) allows a person with use of only one hand to type efficiently on a PC. Left- and right-handed versions are available. Software that re-maps keyboards to Dvorak layouts is also available. [13]

Individuals with motion difficulties also benefit from the use of windowed "point-and-click" controls of computer systems. Pointing devices have been developed that follow the point a person is looking at on the screen. Using such a pointing device and a switch, actuated with the chin or by blowing on a straw, a quadriplegic can control a computer or use a computer to dial telephone calls.[14]

E. Cognitive Disabilities

Some individuals have defects in information processing capabilities that affect memory or reasoning. Increased complexity of communications devices, with telephones having multiple

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[12] See **http://www.augmentative.com/acs-swk.htm**, which describes the Winmini keyboard as: "for people who need a smaller keyboard than the standard IBM/compatible computer keyboard, a WinMini plug-in is the perfect solution."

[13] Source: University of Washington, Adaptive Technology Lab in the Computing Resource Center (CRC), at **http://www.washington.edu/tech_home/atl/DOCS/atl.use.html**.

[14] The same University of Washington website also contained the following statement: "HeadMaster (Prentke Romich Company) and HeadMouse (Origin Instruments) allow hands-free operation of a Macintosh or PC (HeadMouse only). A light-weight headset (HeadMaster) or a reflective dot worn on the forehead (HeadMouse) translates head movement to the mouse pointer. A variety of switches can be connected to emulate the mouse button."

operating modes or the need to remember passwords and command sequences, reduces accessibility for such individuals.[15]

F. Exceptional Cases

Combined or especially severe disabilities create added difficulties that cannot be easily dealt with using off-the-shelf solutions. Consider the plight of an individual who is both a quadriplegic and blind. Tools using point-and-click displays, usually of great value to a quadriplegic, cannot be used nor can Braille readers. Rather, solutions must be based upon audio signalling and limited control from chin switches or sip switches. Obviously, the market for such solutions is very limited — because people with multiple disabilities that limit communications comprise a small subset of those with disabilities. Yet, such individuals comprise a large portion of those that have difficulty using telecommunications.

The lack of off-the-shelf equipment to meet the needs of people with multiple disabilities is not a result of a market failure.[16] Rather, such devices are naturally expensive because they must be customized. The solution is direct subsidy either by philanthropy or the government.

G. Concluding Thoughts

A wide range of disabilities limit people's abilities to use telecommunications. Modern communications equipment (more generally information technology) has brought enormous benefits to people with disabilities. Unfortunately, the world is not perfect. The telephone is poorly matched to the needs of the deaf. Windows and the graphic web pages are wonderful for the motion disabled but create difficulties for the vision impaired. Some people need small keys, and some people need big keys. Any attempt to improve the current situation by regulation must take into account two fundamental truths:

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[15] Of course, some elements of added complexity, e.g, memory dialing, can alleviate the problems encountered by those with cognitive disabilities.

[16] In terms of economic jargon, developing specialized terminal equipment for such people would not meet a Kaldor-Hicks criterion — the benefits, measured by willingness to pay, will not match the costs.

- Innovations in information and communications technologies have brought enormous benefits to those with disabilities. Any policy that weakens the incentives for innovation will harm both those with disabilities and the larger society.

- Disabilities create conflicting needs. Unlike the case with building accommodation, where a visual alerting system does not interfere with an access ramp, a manufacturer cannot simultaneously build a PCS phone with both large, separated keys and small, closely spaced keys.

III. Potential Adverse Consequences of the Proposed Rules

This report provides an economic assessment of the Telecommunications Accessibility Guidelines the Access Board has adopted and the FCC has proposed.[17] Our analysis suggests that the approach embodied in the Accessibility Guidelines is not likely to enhance access to telecommunications and customer premises equipment for persons with disabilities who have difficulty using the telephone or are unable to do so. Indeed, the proposed approach may well thwart advances in accessibility as suppliers act to minimize regulatory risks in optimizing their investments in new product technologies. At the same time, the approach embodied in the Guidelines would carry high compliance costs; such costs represent resources that might alternatively contribute to greater well-being for persons with disabilities affecting the use of the telephone under a more productive approach.

We have identified five economic harms that would follow as a consequence of implementing the FCC's implementing the Access Board's guidelines:

- Damage to the innovation process,
- An inefficient shift in the balance between larger and smaller firms in the electronics industry,
- Encouragement of the export of design and manufacturing employment,

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[17] *See* Telecommunications Act Accessibility Guidelines, 36 CFR Part 1193 [Docket No. 97-1] RIN 3014-AA19.

- Forced inclusion in equipment of a complex assortment of multiple and sometimes conflicting features, and
- Substantial compliance costs.

We consider each of these five harms in turn.

A. Slowing Innovation

Innovation is an engine of economic process and is an area in which the United States has a comparative advantage. Any regulation that would affect the innovation process should be suspect because modern assistive technology rests upon the foundation of general innovation in information technology.

The Access Board's guidelines would insert additional steps for review and documentation in the product design process. These additional steps would slow the movement of products to market and may make some marginal but otherwise potentially viable products unprofitable. Indeed, under the proposed rules, some innovations would never make it to the marketplace. For example, a small cellular/PCS phone with small keyboard, small display and no backlighting, might be quite useful for people with mobility disabilities who desire the convenience of small size and long battery life. But, such a unit would be less accessible to those with vision disabilities than would other designs with larger keyboards and backlit displays.

B. Biasing Firm Size

Enforcement of the proposed rules would probably result in a disproportionate differential burden on large firms. Small firms have more informal management structures and are less likely than large firms to put in place formal compliance programs. In addition, it is unlikely that the FCC or advocates for the disabled would have the political will to impose significant penalties on small firms. Establishing regulatory programs that bias this balance are likely to harm our economy.

C. Exporting Jobs

Although the proposed rules appear to take into account concerns that design and development would be undertaken outside the United States and are written to apply to equipment so designed, we see significant loopholes. One loophole is generated by the practice of building equipment out of high-level subassemblies or kits. If a domestic manufacturer chooses to build a system using high-level subassemblies, such as a display screen or a keyboard, the manufacturer can reasonably argue that its design process was limited to the selection of that subassembly from among those available on the world market. A product could consist of a collection of a few such high-level subassemblies together with some software and custom enclosures. The design of the subassemblies would not fall under the proposed rules.

A second loophole occurs if a product is highly successful outside the United States. Consider a hypothetical example involving the telecopier, which has become almost ubiquitous for businesses. Assume that the telecopier had not yet been brought to the market but that firms were considering bringing such a product to the market. A firm subject to the proposed rules might hesitate —fearing that it would be unable to demonstrate that it had fully complied with the requirements for accessability for the blind. However, once the telecopier had succeeded outside the United States, consumer and firms would bring pressure to bear to allow the import of such equipment (or consumers would purchase such equipment overseas and bring it to the United States as personal property). Successful products developed outside the reach of the proposed rules cannot be kept secret from American consumers. Consequently, markets for such products would open in this country, but, manufacturers in the United States would have lost the first-mover advantage.

D. Encouraging Development of Hard-to-Use Equipment

The Accessibility Guidelines call for efforts (*i.e.*, expenditure of scarce resources) to endow each product model with the capacity *simultaneously* to address the needs of persons with many different kinds of disabilities. Where such efforts are impractical, the Guidelines require efforts (again entailing expenditure of scarce resources) to document that impracticality, presumably in a manner sufficiently thorough as to withstand legal challenge and avoid financial penalty.

Instead of breaking a big problem into a series of more solvable smaller ones, the approach embodied in the Accessibility Guidelines make every problem a big one not easily amenable to practical solution. Instead of promoting growth in markets for specialized products capable of producing improved access for individuals with disabilities, the current approach raises barriers to market growth and innovation for all products.

Consider the problems of making a pager accessible to both the deaf and the blind. Standard alphanumeric pagers are quite convenient for the deaf and profoundly hearing impaired. They can carry short messages in text form and can alert the user that a message has been received through silent vibrations. A similar pager is almost useless for a blind individual — the message on the LCD display is unreadable. However, the blind have other options —including pagers that deliver spoken messages and cellular and PCS phones. Requiring that every pager be capable of meeting the needs of both deaf individuals and of blind individuals would burden every pager with unnecessary elements. Putting more modes in equipment —as suggested by the proposed rules —would make products harder for all consumers to use. These increased difficulties are likely to disproportionately affect those with cognitively disabilities. Additionally, costs would rise.

An alternative approach — permitting firms and markets to create a portfolio of communications products and permitting consumers to select from that portfolio the product that best meets their needs — is far more likely to meet the need of those with disabilities than a one-size-fits-all mandate.

One of the most telling critiques of the one-size-fits-all approach was offered in comments to the Board by the American Speech-Language Hearing Association to the Access Board:

> ASHA supports the scope of the Section 255 guidelines regarding application to all telecommunications equipment and customer premise equipment (CPE). ASHA, however, would disagree to a blanket application of these guidelines to the manufacturers of specialized customer premise equipment (SCPE). We find no reference in the Communications Act of 1996 indicating SCPE are covered; therefore, the Access Board's recommendations go beyond the intent of Congress. The reference to SCPE in the current guidelines should be omitted as it is not part of the legislative intent and may unintentionally cause harm to the individuals this legislation is written to protect.

ASHA goes on to argue that the design of CPE requires tradeoffs and that it is unwise to burden this design tradeoff with extra requirements for universal access:

> SCPE is by definition and nomenclature "specialized;" SCPE is often tailor-made to fit the needs and lifestyle demands of a given individual. SCPE manufacturers are the innovators in the area of telecommunications accessibility, designing technology to meet user needs regardless of market size or potential for mass distribution. Due to this extreme regard for individualization, SCPE manufacturers' financial assets, staff resources, and market size are often significantly less than that of the more generalized CPE manufacturer. SCPE permits accessibility for a given defined set of users who need a different format to input/output telecommunications information. SCPE permits a specific format and mode of communication which differs from that used by general population. *Changing that format or adding other modes may not be technologically or financially feasible and unnecessary in meeting the needs of the defined user. In fact such changes may even be detrimental to the purpose of the equipment.*
>
> ASHA Comments Docket 97-1 (emphasis added.)

We could provide other quotes from manufacturers of SCPE. But, the point is clear — advocates for the disability community recognize that applying a one-size-fits-all approach to the design of some communications devices would harm rather than help those with disabilities. The conclusion to be drawn from such analysis is much more general: applying the one-size-fits-all philosophy to the general market would harm all consumers — those with and without disabilities.

E. Compliance Costs

The proposed rules would generate substantial compliance costs. Firms would have to document their product design and development process. Perhaps most costly, a mechanism would have to be put in place to review complaints about possible noncompliance and to referee disputes between manufacturers and others regarding noncompliance. While we believe that they constitute the smallest element in the negative impacts of the proposed rules, the compliance costs are easier to quantify than the other costs of the proposed rules. In Section VI below, we discuss this in greater detail.

IV. Equity and Market Concerns

In this section, we describe the social and market concerns created by accessibility needs and communications services and technologies. We believe that market failures account for only a fraction of the situations where people with disabilities do not obtain the telecommunications equipment and services best suited to their needs .[18] We think the principal concerns arise from the following:

- Market failures:
  - — Transaction cost problems;
  - — Deficiencies in training designers; and
  - — Informational failures at the time of purchase.
- Equity concerns:
  - — Affordability for uncommon cases; and
  - — Perception of individuals with disabilities.

A. Market Failures

Market failures are often ascribed to markets that fail to produce the results commentators desire. But, technically speaking, a market failure occurs when the a competitive market does not produce an efficient *supply* of particular goods.[19] One common cause of market failure is transaction costs — for example, it may cost a consumer more to search out a product than that product delivers in value. We believe that several specific market failures play a significant role in limiting access by those with disabilities to telecommunications products and services.

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[18] Commissioner Harold Furthgott-Roth stated "This particular area of regulation may well be a rare instance of where the involvement of federal government introduces efficiencies unlikely to develop in the market."

Similarly, Commissioner Powell stated, "I know that this is an area where free market forces alone are unlikely to address the specific needs of individuals, who solely because of life's unpredictability and randomness find themselves restricted by physical adversity. This is an area where government can help this community enjoy the fruits of independence that the seeds of telecommunications can yield and that the Act envisioned. The principle of universal service is ultimately inclusion, and the disabled community should not be overlooked."

We believe that social concerns in this area are motivated by more than simply concerns about efficiency and market failure. However, a focus on efficiency is key to ensuring that those with disabilities benefit in the long run.

[19] Many factors, including monopoly, externalities not reflected in the market, transactions costs, can lead to market failure.

1. Transaction Costs

A rough calculation illustrates the nature of such failures. There are approximately one million payphones in the United States and about one million hearing aid users who use telecoils. If we assume that a payphone has a life in the field of five years, then 200,000 new units are placed in the field each year. Expanding the capabilities of a payphone to support a telecoil adds about one dollar to the cost of a payphone. The added cost works out to 20 cents/year — roughly half the cost of a payphone call — to give each telecoil user the option of using every payphone. Based upon reflection and conversations with telecoil users, we judge that telecoil users would be willing to pay this small amount. The problem is not that these users are not willing to pay but that the market does not permit their preferences to be expressed efficiently. Similar problems abound. Consider the issue of making telephones in hotels and other public places hearing-aid compatible. The arithmetic is similar — but assuring hearing-aid compatibility for telephones in hotels would be more costly because there are more hotel-room telephones.

Consider, in contrast, the alternative of putting a TTY in every hotel room. TTYs cost about $200, and there are three million hotel rooms and one million TTY users. If a TTY lasted five years, the cost putting a TTY in every hotel room works out to $120 per TTY user per year. Given that many TTY users carry their own portable unit with them and that hotels can purchase a few TTYs and provide them to consumers at the time of check in, it appears clear that installation of TTYs in all hotel rooms would be wasteful. Most of the benefits of such universal installation can be gained by less costly approaches. The lack of TTYs in every hotel room is not evidence of a market failure, but rather is economically rational — the need is not compromised, but is provided at a lower overall cost to society.

2. Deficiencies in Training Designers

One intervention that would increase the supply of accessible telecommunications equipment is to train designers in accessability needs and the principles of accessible design. Here, the demonstration that such training would remedy a market failure is difficult. Nevertheless, it is our opinion that such is probably the case. Training generates no bureaucratic follow-on, and operates in the earliest stages of the product life cycle — when changes are least costly.

3. Information Failures at Time of Purchase

Failures can also occur at the point of purchase. For example, if retailers fail to explain limitations of communications equipment or fail to point out equipment that would better serve the needs of a consumer with a disability, then such consumers would be unlikely to obtain the equipment that best serves their needs. Similarly, if consumers are unaware of the alternatives available in the market, they may settle for equipment that is suboptimal. Education of sales people and improvements in advertising, point-of-sales displays, and sales literature are the steps are most likely to remedy this shortcoming. Such training could be a formidable challenge because many retailers have high staff turnover and manufacturers, for the most part, do not own the retail outlets that provide their products.

B. Equity Concerns

In addition to market failures, there are concerns about equity — to what extent should we as a society ensure access to telecommunications equipment and services over and above that which would be provided by the market?

1. Affordability

The fact that mass market products do not meet needs of those with multiple disabilities or exceptionally rare disabilities is not due to market failure. Rather such individuals need specialized or custom solutions. For example, providing an effective communications terminal for someone who is both blind and suffers from cerebral palsy in all probability will require unique equipment to meet the needs of that individual. Similarly, individuals with such multiple disabilities often have limited incomes and thus a limited ability to pay — thereby reducing the feasibility of market solutions. We believe that the economically rational tool to deal with such unique needs is subsidy — either through private philanthropy or public subsidy. Several such programs exist.[20]

2. Appearances

[20] For example, chapters of the National Multiple Sclerosis Society make equipment available to some people with MS and some insurance policies pay for assistive devices.

People are also concerned about perceptions and equal treatment. Some would prefer a world where those with disabilities can satisfy as many of their needs as possible with off-the-shelf equipment meant for general consumption — even if such arrangements sacrifice efficiency. We disagree with this view. We believe that restricting the supply of products to assure that products appear equal harms many with commensurate benefits.

V. ECONOMIC CRITIQUE OF THE PROPOSED GUIDELINES

A. Competitive Markets for Telecommunications Equipment Have Produced Substantial Benefits for All Consumers

Product improvements and market innovation have enhanced accessibility and increased economic welfare for all telecommunications equipment consumers. To the extent that the process of innovation is inhibited, *all* consumers are likely to suffer losses of economic welfare as a consequence of their not having new and improved products and services for use on a timely basis.

The proposed Accessibility Guidelines raise a variety of barriers to new product development and innovation. By increasing product development costs, they raise the revenue hurdle a successful innovation must traverse. By diffusing development efforts, they inhibit productive specialization of effort and function. By raising the prospect of regulatory second-guessing of managerial decision making, they discourage risk taking and encourage compliance efforts that follow the path of least resistance.

Accessibility guidelines should attempt first to do no harm and to afford dynamic forces of market competition maximum scope for enhancing accessibility capabilities. If the past serves as a guide, policies designed to spur rapid product development and innovation hold the greatest promise for meeting the telecommunications accessibility needs of persons with disabilities.

B. Costs of Requiring That Every Product Be Engineered to Meet Every Need

The Accessibility Guidelines require that equipment possess certain characteristics to be deemed *accessible* by individuals with disabilities. To be accessible, equipment must be operable without

by those vision, hearing, or speech and with limited manual dexterity or limited cognitive skills. Defining specific disabilities that equipment capable of meeting various accessibility needs would address is unexceptionable. The problem with the Guidelines is that they are interpreted to mean that *every* piece of equipment is subject to the requirements for accessibility and, moreover, that *each* piece of equipment must be engineered so as to satisfy *all* of the disparate (and often conflicting) accessibility needs of persons with different disabilities.

Telecommunications equipment manufacturers produce a large number of different equipment models. To require that significant resource expenditures be incurred to ensure that each and every model complies with the requirements for accessibility would impose substantial compliance costs. Economically rational compliance efforts would, in contrast, likely focus on the discovery and embodiment of particular modifications to particular equipment models to enable them to serve the accessibility needs of individuals with particular disabilities or combinations of disabilities. A strategy that requires that costs be incurred to attempt to engineer every piece of equipment to meet every accessibility need would, in all likelihood, not produce the desired results and would waste scarce resources that could be more productively deployed in advancing accessibility needs.

The barriers to new product development and innovation that would occur as a byproduct of this approach would frustrate the primary source of progress in addressing the accessibility needs of persons with disabilities — new products with expanded and improved capabilities.

C. The Costs of Universal Redundancy and Selectibility

Requirements for the inclusion of multiple capabilities pose difficult design issues. Consider, for example, the provision of enhanced audio for persons with hearing disabilities. One approach might be to extend the volume range, thus affording the listener greater ability to increase the volume. If a person without impaired hearing accidentally turns the volume control up with this capability, he or she might experience discomfort or disturb others with the extra loud audio. Alternatively, provision of this capability might be triggered by a switch, but added selectivity raises cognitive problems as the complexity of equipment increases. Demonstrations that multiple objectives such as these (*e.g.*, provision of multiple selective features *and* simplicity of operation) are not readily

achievable would not likely be simple or inexpensive, especially when account is taken of the need for such analysis to withstand external scrutiny.

Instead of simplifying the tasks that need to be addressed to produce real progress, the proposed approach would complicate the search for solutions and set the bar so high that few suppliers, behaving rationally, are likely try to jump over it. The prudent tack would be simply to avoid altogether the heightened risk of capital expenditures in the new environment and divert engineering resources to the task of documenting why the laws of physics and economics do not permit ready resolution of incompatible objectives.

D. The Costs of Establishing Affirmative Duties Throughout the New Product Development Process

The Guidelines compel attention to accessibility issues at all stages of product development and manufacture for every product. In contrast to tests for compliance of equipment with various well-established technical standards such as those for radio interference, the "readily achievable" criterion presents formidable challenges for compliance. Consider an analysis of whether a particular functionality can be provided without audio. It may be technically feasible to insert a voice chip and convert voice into text. A person with a hearing disability could then use this voice-to-text translation. Suppose, however, that the attendant cost increase threatens the economic viability of the product. If a company judges that incorporating accessibility features is not readily achievable because the required changes make the product likely to fail in the market, it would have to build a file documenting that judgment. That decision calculus would necessarily be subject to second-guessing. An objective threshold for economic viability is hard to conceive in the absence of a market test. Tests for economic viability are hard to specify and differ among producers.

Tests for product compliance would also have to be developed and their legal viability assessed. Compliance would be less readily achievable the stricter the standards for compliance. Thus, in addition to costs associated with determining whether accessibility functions are readily achievable and, if not, documenting their infeasibility — what might be termed the direct costs of compliance

— there are also likely to be substantial indirect costs. Firms would need to develop administrative and scientific authentication processes to address compliance requirements.

The Guidelines envision that as new capabilities are invented, their inclusion in particular products would be required if "readily achievable." Such inclusion may increase production costs, raise prices, reduce product demand, and lower profitability. Whether the increase in costs would be sufficient to render such inclusion *not* readily achievable would depend on the specific circumstances and would be difficult to determine.[21] Verification of achievability would presumably entail a market test. Validity of such a market test could be subject to challenge. Was marketing adequate? Was product design optimal? The issue could turn on the adequacy of documentation; hence, there would predictably be tendencies toward a surfeit of documentation. The ultimate result may intensify efforts to ensure that business decisions were thoroughly and convincingly documented rather than any expansion of the well-being of persons with disabilities.

The Act also calls for equipment to be compatible with peripheral devices typically utilized by persons with disabilities. Certain types of equipment of a particular type could be made to function compatibly with certain types of peripheral equipment. A portable phone with a "hands-free" capability might, for example, work effectively with a hearing aid. On the other hand, other models may not be capable of functioning easily with peripheral equipment. A portable phone held in proximity to a hearing aid may produce an objectionable hum that may be difficult to remedy. Efforts to make the latter type of device compatible with peripheral equipment are likely to be costly and produce minimal benefits in terms of improved functionality; the misallocation of scarce research efforts under this approach would produce a deadweight loss as suppliers are compelled to deploy resources to explain why incompatible objectives are not readily achievable.

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[21] Capabilities change over time. Product lead times are often such that capabilities that are not readily achievable when products are being designed may subsequently become achievable. The point at which capabilities improve sufficiently to permit specific capabilities to be embodied in equipment is not a bright line, but subject to debate and interpretation — an additional likely bone of contention in terms of justifying and second-guessing decision-making.

The need to jump through added hoops would also likely retard the introduction of improved products — even those products for which functional compatibility is clearly achievable. Delays in introducing new products reduce consumer welfare, producing economic losses in addition to the deadweight losses from nonproductive and thus wasteful documentation exercises.

E. The Need to Optimize Technical and Economic Tradeoffs in the Implementation of Section 255

The Accessibility Guidelines do not take adequate account of the constraints imposed by technical and economic tradeoffs in the production and supply of telecommunications equipment. Such constraints necessitate choices in technology and product features to address customer needs efficiently and economize on scarce productive resources.

While advances in microelectronics create new ways of implementing systems, at any point in time there are tradeoffs between physical size and various product capabilities. Small physical size limits memory capacity, battery size, and the number of different functions that can be embodied in any electronic device. To add a function requires additional read-only memory, more power, and more board space. That entails sacrificing other capabilities or increasing physical size. The imposition of a minimum number of functionalities would restrict a manufacturer's ability to offer customers other desirable product features (*e.g.*, light weight, small size, convenient storage, ease of operation). These tradeoffs affect persons with and without disabilities.[22]

The Guidelines require that equipment be usable with various peripheral devices that enable their use by persons with disabilities. One problem for compliance with this aspect of the Guidelines is that equipment is highly varied and often not standardized. Lack of commonality makes it difficult for different peripheral devices to interface with other pieces of equipment. At the same time, lack of standardization reflects a highly dynamic marketplace in which new products with new capabilities (requiring new serving arrangements) are being introduced all the time. Again, there is a

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[22] For example, persons with mobility disabilities derive significant benefits from lightweight wireless communications equipment. These benefits are necessarily sacrificed to the extent that added features to address other accessibility needs increase size and dissipate battery lives more rapidly.

tradeoff that needs to be recognized and optimized: It is possible to have more standardization and the beneficial consequences in terms of the peripheral device accessibility associated therewith, but most likely at the cost of reduced market dynamism and product innovation.

VI. COSTS OF THE PROPOSED GUIDELINES

In this section we identify the costs that would be imposed on society by implementation of the Guidelines. In thinking about such costs it is useful to divide such costs into two categories— actual expenditures (*e.g.*, the cost of added testing) and harmful, although unintentional, consequences of having the rules in place (*e.g.*, some products will not make it to the market).

A. Estimating Compliance Costs

To estimate compliance costs likely to be incurred under the Accessibility Guidelines, it is useful to describe in general terms the production process typically involved in producing the kinds of telecommunications equipment covered by the Act. This will provide some feel for kinds of work activities performed during the course of product development and manufacture. While the production process varies across product development efforts — with some projects involving only simple modifications of existing products with a truncated development period, other projects involve major systems and component development over an extended period, and still others entail the optimization of difficult design and manufacturing tradeoffs — it is nevertheless possible to generalize in a constructive way. This generic view then can supply the base from which to gauge the effects of the Guidelines' requirements.

The production process for telecommunications equipment can be broken down into a number of basic stages. We describe them in the logical sequence in which they occur, although actual production processes tend to be more complex, typically involving any number of information and design feedback loops, frequent design modifications affecting materials and component requirements, combinations of required work skills, and the organization of manufacturing and shop facilities. Development processes for software — and equipment in which software comprises a large fraction of the value added by the manufacturer — also typically differ somewhat from the general description offered here.

B. Description of the Production Process

Resources are limited, and product development filters the large number of potential products down to those for which the technical, financial, and marketplace risks and rewards are deemed most attractive. The product development process entails constant decision making and concomitant data collection and analysis. The process of reducing a fluid idea to decision-relevant data and specifying the detailed instructions required to fabricate equipment components as well as the component fabrication equipment is very costly. The process of deciding which design features to ignore and which to risk spending on for the next stage of development itself constitutes a significant cost.

We divide the production process into four stages: research, specification and design, prototyping, and manufacturing startup. Research is the most basic step. It includes studies of physical phenomena (such as how metals harden) and studies of consumer behavior (such as how many display menu choices are optimal). Specification and design is the stage at which the concept of a product is conceived and the implementation of the product is developed. Prototyping is the building of one or a few test models of the product and the verification that the product performs as desired. Manufacturing startup is the transfer of the design from product development to manufacturing. It includes developing manufacturing processes and support materials such as user manuals.

C. Impacts on Work Activities

Section 255 requires that manufacturers "design, develop, and fabricate equipment to be accessible."[23] The proposed Guidelines state that "[m]anufacturers shall evaluate the accessibility and usability of . . . equipment . . . and shall incorporate such evaluation throughout product design, development, fabrication, and delivery *as early and consistently as possible.*"[24]

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[23] *Cf.* Section 255(b): " A manufacturer . . . shall ensure that equipment is designed, developed, and fabricated to be accessible . . . ."

[24] Guidelines at §1193.23, emphasis added.

The Guidelines require that manufacturers "provide employee training appropriate to an employee's function."[25] This requirement would affect all stages of development. While the clerk or general manager in charge of some common back-office function might, under this rubric, merely require a level of sensitivity training and a survey of accessibility issues, the training "appropriate to the function" of an employee in basic research might require the same level of scientific sophistication and depth of knowledge that the researcher brings to their other work, a significant educational undertaking.

The Guideline's expectation that the focus groups and samples each firm uses for market research include individuals with disabilities would affect the research stage. The impacts of this requirement include not just the reworking of existing marketing and scientific research methods, but also the additional work required to regularly locate, assemble, and successfully interact with individuals with every type of disability. While we agree, and recommend below, that firms should educate their designers to the needs of people with disabilities, the Guideline's requirements appear burdensome and excessive.

The actual process of product specification and design would be significantly altered to accommodate accessibility needs for every disability in every product. For most companies, this would also affect existing strategies for market segmentation, entry and exit. Most important, it is likely that formal procedures would be put in place to document the consideration of each new product feature, however tentative, and to demonstrate that each dimension of added accessibility either was duly implemented as early as possible into the evolving design or was not readily achievable. Documentation and evaluation efforts would likely expand substantially.

The functional interdependencies among different parts of each product — among multiple products on each technological platform, and between the product and the production infrastructure in place — are made explicit and subjected to formal corporate decision making at the specification and design stage. Thus, the costs of each new accessibility capability would become understood, as would the costs — characterized as common planning expenses — incurred earlier in the process

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[25] Guidelines §1193.25(c).

in which alternative approaches were abandoned or delayed due to universal accessibility concerns. The prudent corporation would likely install layers of formal reviews and documentation to be evaluated by the legal or regulatory departments.

The explicit economic costs of compliance would ultimately be felt most severely by the firm in the specification and design and prototyping stages. The accessibility problem ultimately requires actual physical testing of proposed models by disabled individuals. This can only occur after prototypes have become available. As contemplated by the proposed Guidelines, every prototype model would have to be tested for compliance on every dimension of accessibility. Due to the very nature of the prototyping process, this evaluation activity must occur before other engineering issues have been stabilized. Presumably, if design parameters change after accessibility testing has been performed, this testing must be repeated to ensure the product is still in compliance. This represents a departure from the distribution of risk in the new product development cycle the industry has relied upon to date. Heretofore, a firm could settle fundamental user interface issues at the early prototype stages, then shift attention to issues of cost, performance, and ease of manufacture in the later phases of final product design and manufacturing startup. If later changes in design for cost or performance considerations resulted in a change in usability for consumers, the firm would at worst face the prospect of reduced consumer acceptance or outright product failure. In the new world proposed by the Guidelines, the firm would also be in violation of the law.

In contrast to other stages of production, the Guidelines have very specific recommendations for the distribution, sales, and support of new product introduction. The requirements include not only the training of people involved in sales and product support to interact with individuals with any of a broad range of disabilities according to standards that are currently unknown and may be expected to change and the development of a concomitant spectrum of sales and user information in a variety of modalities. We judge that these elements of the Guidelines would be less burdensome; and we doubt that they would have significant negative impacts. Indeed, we notice that many firms are providing such information today.

D. Estimates of Compliance Costs

1. Sizing the Market

It is impossible to gauge the full extent of the equipment manufacturing activity that would ultimately fall under the yoke of any formal Section 255 compliance requirements. Indeed, it is likely that a whole cottage industry would form around expanding the set of products affected. Among the types of telecommunications products currently manufactured for sale or use in the United States, it appears that the language of Section 255 could, at a minimum, arguably encompass subsets of at least the following:

- Ordinary, portable, mobile, and pay telephones;
  - — Telephone central office equipment;
  - — Terrestrial, satellite, and cable set-top boxes;
  - — Computer software and hardware, including peripheral devices such as video displays, keyboards, printers, and audio speakers;
  - — Modems and video codecs; and
  - — Pagers and personal communications devices.

Below we use two separate approaches to identify the scale of economic activity affected by the Guidelines. The first approach is based upon Census data and corporate reports. The second approach, which we use as a check on our first approach, is to examine the volume of Part 15 and Part 64 devices registered at the FCC each year.

We gathered information on sales and research and development spending from the annual reports of three major communications products manufacturers: Motorola, a manufacturer of radios, computer chips and network infrastructure equipment; Lucent, the recently independent equipment manufacturer that was formerly known as AT&T Technologies and before that was known as Western Electric; and Microsoft, the computer software manufacturer whose most well-known product, Windows 95, contains software for remote access computing, Internet access, faxing, email, and other communications tasks. The results of this tabulation are shown below

Firm	R&D Expenditures (millions)	Sales (millions)	R&D Expenditures As a % of Sales
Lucent	$4,047	$26,360	15.4%
Microsoft	$1,925	$11,358	16.9%
Motorola	$2,394	$27,937	8.6%
Total	$8,366	$65,655	12.7%

The tabulation above shows that representative firms spend about 10 to 15 percent of their gross revenue on R&D activities. In our analysis below, we assume that product design and development costs total 12 percent of industry gross revenue.

The Census Bureau classifies manufacturing industries by a code known as the standard industrial classification (SIC). SIC codes may be either two-digit, three-digit, or four-digit. Three-digit codes are subdivisions of two-digit codes. For example, SIC code 36 is electronic and other electric equipment and code 361 is electrical distribution equipment. The relevant two-digit code for understanding the effects of the proposed rules is SIC 36 — electronic and other electric equipment. The Census Bureau reported that firms with this SIC code accounted for $300 billion worth of industry shipments in 1995.[26] But, clearly this SIC code includes other activities besides tele-communications equipment. The three-digit SIC codes 357 (computer and office equipment) and 366 (communications equipment) include the economic activities primarily affected by the proposed rules. The Census Bureau reported that the value of industry shipments in 1995 for code 357 was $90.2 billion and the value of shipments for code 366 was $58.8 billion, for a total value of shipments of $149 billion. Assuming a 12 percent ratio of R&D costs to shipments, we obtain a figure associated R&D expenditures for these industries of about $18 billion in 1995. We believe that roughly two-thirds or $12 billion of this R&D expenditure is for products covered by the Guidelines. Even a slight burden on this effort would impose substantial total costs on our society.[27]

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[26] U. S. Department of Commerce, Bureau of the Census, *1995 Annual Survey of Manufactures*, Statistics for Industry Groups and Industries, M95(AS)-1, Table 2, page 1-22.

[27] We note that our analysis using SIC codes 357 and 366 is similar to that used in Appendix E (Initial Regulatory Analysis) of the NPRM to count the number of small business entities that would be affected by the

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If we assume a distribution of the scale of project development projects, we can estimate the total number of projects associated with $12 billion of development costs. We have performed such a calculation — using the model described in Appendix A. We estimate that development of 5,000 products per year would account for $6 to $12 billion in research and development costs. We also estimate with this model, that **compliance costs alone for these projects would lie in the range of $450 to $750 million per year**. We believe that the consumer harms from damages to the innovation process would be much higher.

2. A Lower Bound

To estimate a lower bound on the costs associated with formal compliance with the proposed Guidelines, we need as a starting point an estimate of the number of new products introduced each year in the United States that are likely to fall within the scope of Section 255.

We use the equipment subject to the FCC's Part 68 and Part 15 rules as a conservative surrogate in this regard. The FCC's rules in Part 68 govern the physical characteristics of devices that can be connected to the Public Switched Telephone Network (PSTN), and the rules in Part 15 limit the amount and nature of radio frequency interference that a device may generate. Manufacturers of telecommunications and electrical equipment must ensure that the products they sell comply with these rules before they are marketed in the United States and, therefore, extensive effort is put into designing and testing each product type for compliance. There is thus a strong analogy between the administration of Parts 68 and 15, on the one hand, and the compliance regime embodied in the proposed Guidelines on the other.[28] Moreover, administration of Parts 68 and 15 has been in place for decades now and, subject to qualifications that we spell out in greater detail below, the pool of equipment affected has the advantage of being in many respects a known quantity. Finally, the

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[27] (...continued)
proposed rules.

[28] We emphasize that the analogy is only that: an analogy. We propose to use these costs *merely as surrogates*, not as starting estimates on the actual costs themselves. For example, in many places the Part 68 and Part 15 costs may include equipment which is arguably outside the scope of Section 255. The work involved in isolating the impacts of this extraneous equipment would obviate the advantages of using the surrogate in the first place. And since we argue elsewhere that the actual costs of the Guidelines as proposed is likely a *multiple* of the lower bound we construct, isolating the extraneous content would merely provide a false precision.